Link-State Routing Protocols

Routing Protocols and Concepts – Chapter 10

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Objectives

- Describe the basic features & concepts of link-state routing protocols.
- List the benefits and requirements of link-state routing protocols.

Introduction

In this chapter, you will learn to:

- Describe the basic features and concepts of link-state routing protocols.
- List the benefits and requirements of link-state routing protocols.

Link-State Routing

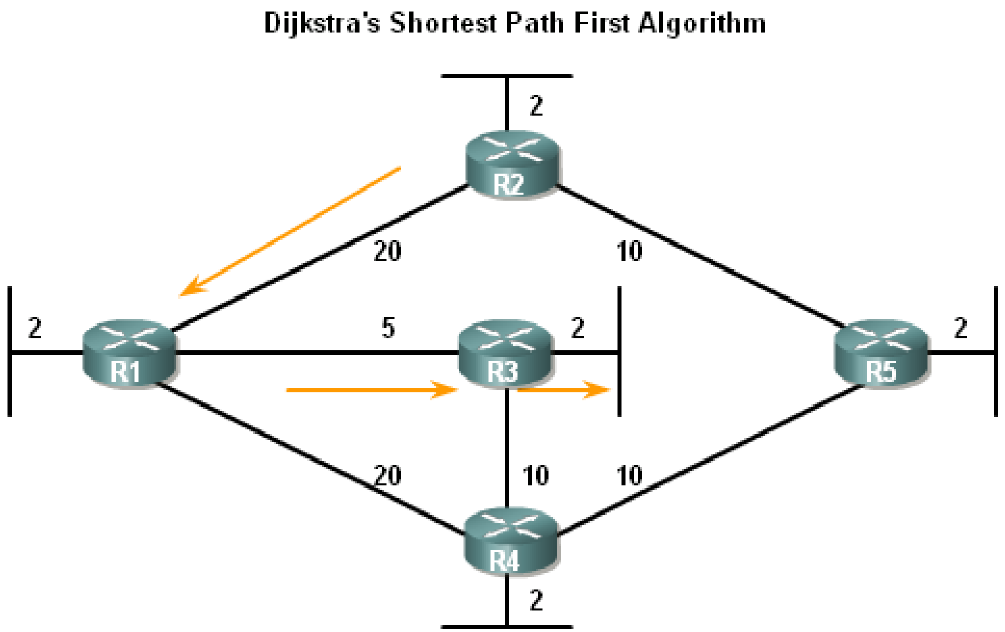
- Link state routing protocols
  - Also known as shortest path first algorithms
  - These protocols built around Dijkstra's SPF

Classification of Routing Protocols

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector Routing Protocols		Link State Routing Protocols		Path Vector
Classful	RIP	IGRP			EGP
Classless	RIPv2	EIGRP	OSPFv2	IS-IS	BGPv4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	BGPv4 for IPv6

Link-State Routing

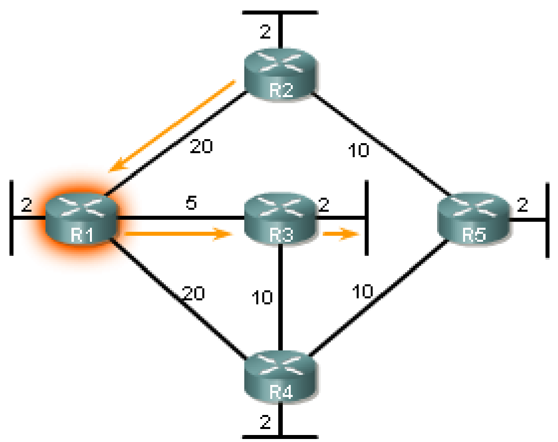
- Dikjstra's algorithm also known as the shortest path first (SPF) algorithm



Shortest Path for host on R2 LAN to reach host on R3 LAN:
R2 to R1 (20) + R1 to R3 (5) + R3 to LAN (2) = 27

Link-State Routing

- The shortest path to a destination is not necessarily the path with the least number of hops



Destination	Shortest Path	Cost
R2 LAN	R1 to R2	22
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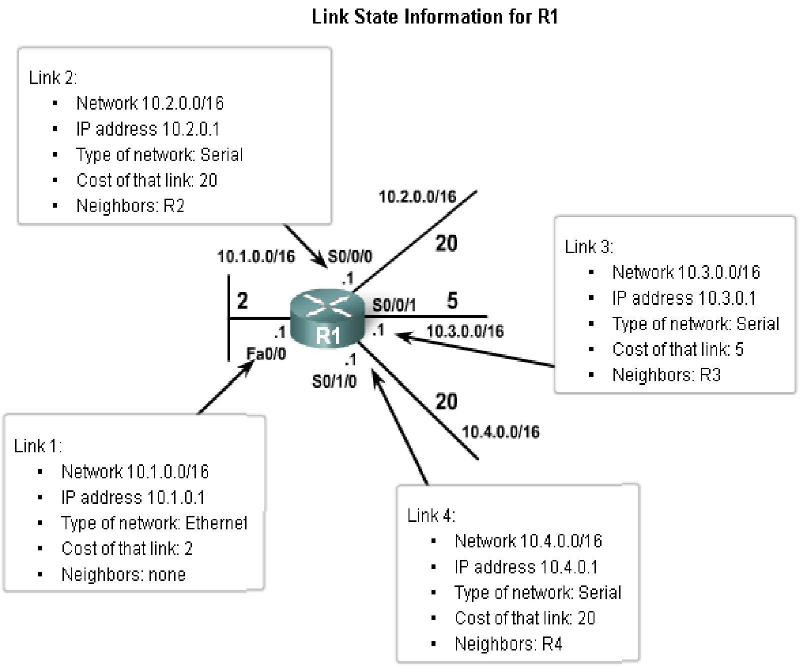
Link-State Routing

- Link-State Routing Process
  - How routers using Link State Routing Protocols reach **convergence**
    - Each routers learns about its own directly connected networks
    - Link state routers exchange hello packet to “meet” other directly
    - Connected link state routers
    - Each router builds its own Link State Packet (LSP) which includes information about neighbors such as neighbor ID, link type, & bandwidth
    - After the LSP is created the router floods it to all neighbors who then store the information and then forward it until all routers have the same information
    - Once all the routers have received all the LSPs, the routers then construct a topological map of the network which is used to determine the best routes to a destination

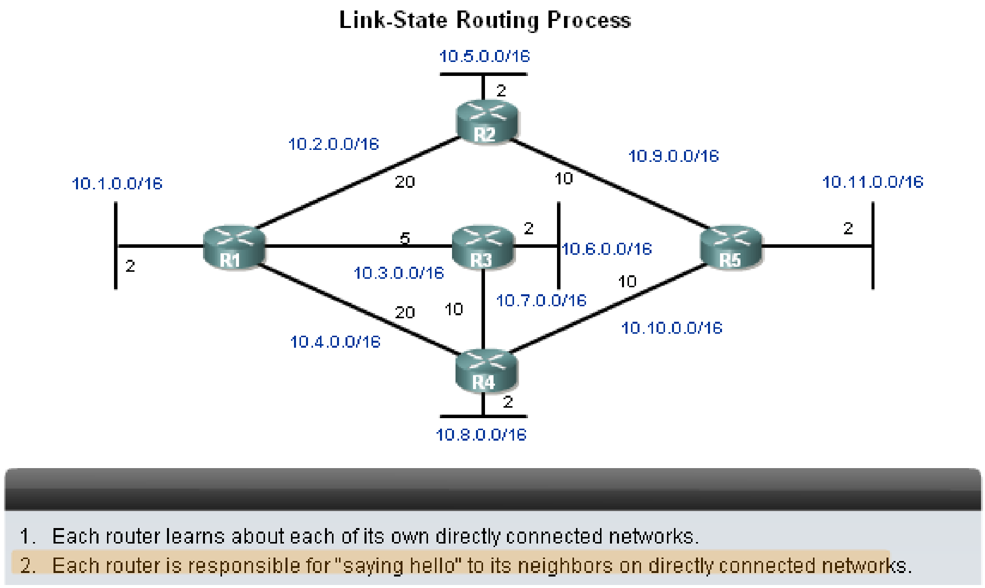
Link-State Routing

- Directly Connected Networks
- Link
  - This is an interface on a router
- Link state
  - This is the information about the state of the links



Link-State Routing

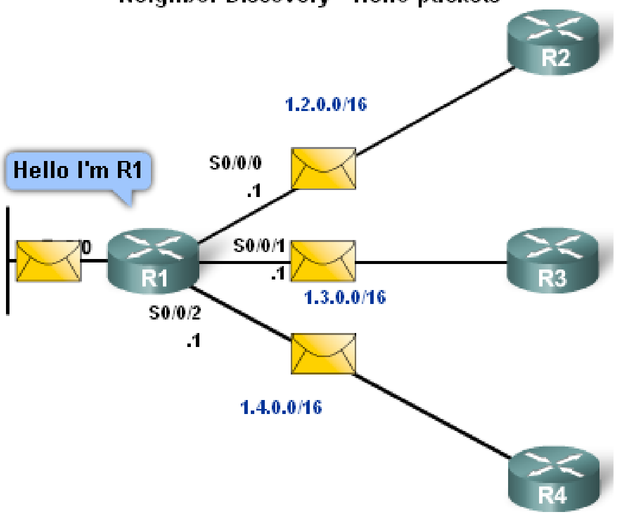
- Sending Hello Packets to Neighbors
  - Link state routing protocols use a hello protocol
  - Purpose of a hello protocol:
    - To discover neighbors (that use the same link state routing protocol) on its link



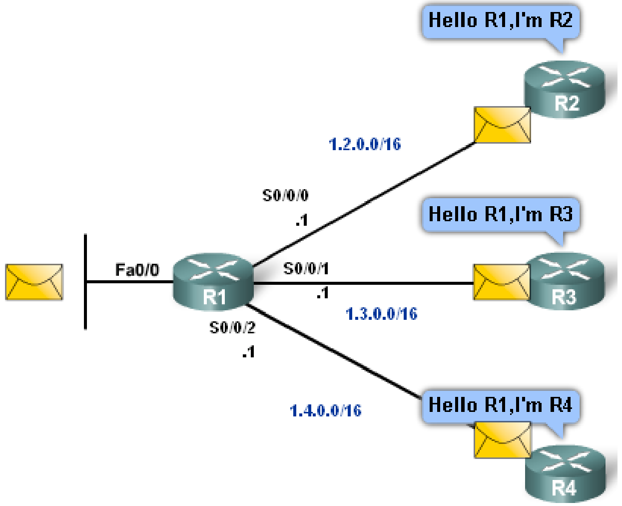
Link-State Routing

- Sending Hello Packets to Neighbors
  - Connected interfaces that are using the same link state routing protocols will exchange hello packets
  - Once routers learn it has neighbors they form an adjacency
    - 2 adjacent neighbors will exchange hello packets
    - These packets will serve as a keep alive function

Neighbor Discovery—Hello packets



Neighbor Discovery—Hello packets

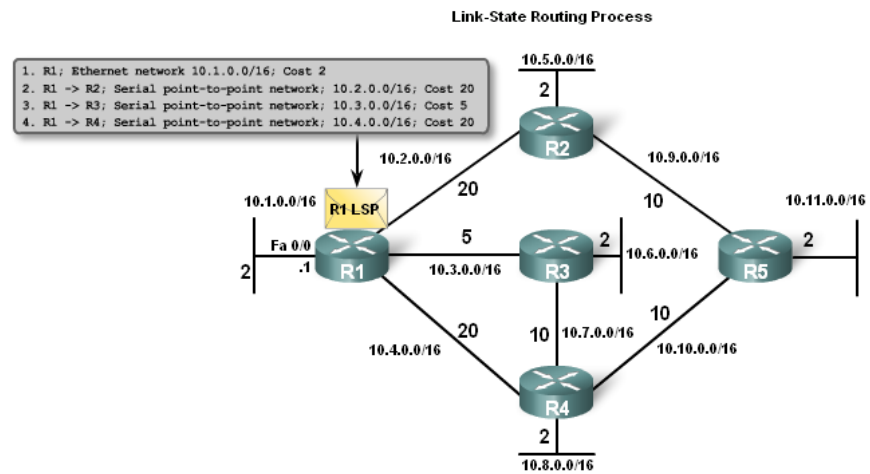


Link-State Routing

- Building the Link State Packet
  - Each router builds its own Link State Packet (LSP)
  - Contents of LSP:
    - State of each directly connected link
    - Includes information about neighbors such as neighbor ID, link type, & bandwidth


Link-State Routing Process

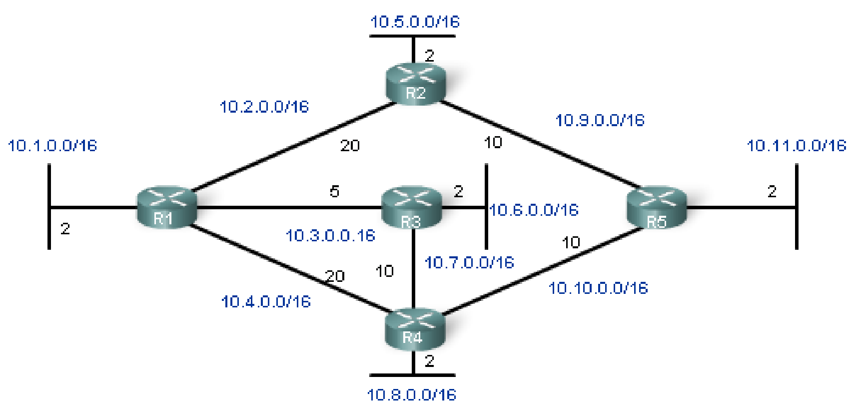
1. Each router learns about each of its own directly connected networks.
2. Each router is responsible for "saying hello" to its neighbors on directly connected networks.
3. Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.



Link-State Routing

- Flooding LSPs to Neighbors
  - Once LSP are created they are forwarded out to neighbors
  - After receiving the LSP the neighbor continues to forward it throughout routing area

Link-State Routing Process



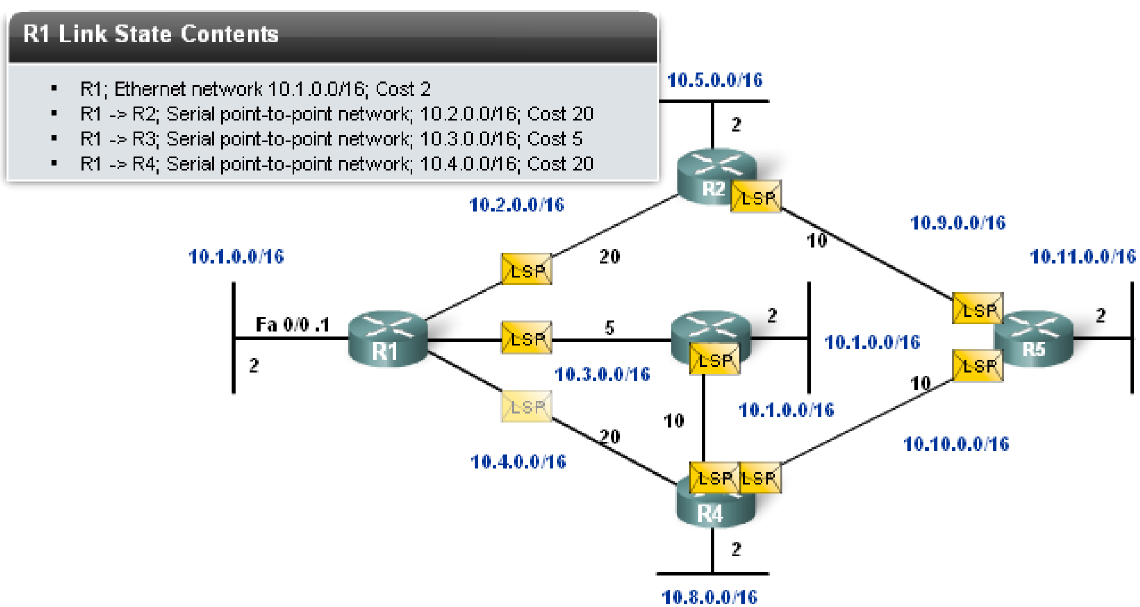
Link-State Routing Process

1. Each router learns about each of its own directly connected networks.
2. Each router is responsible for "saying hello" to its neighbors on directly connected networks.
3. Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.
4. Each router floods the LSP to all neighbors, who then store all LSPs received in a database.

Link-State Routing

- LSPs are sent out under the following conditions:
  - Initial router start up or routing process
  - When there is a change in topology

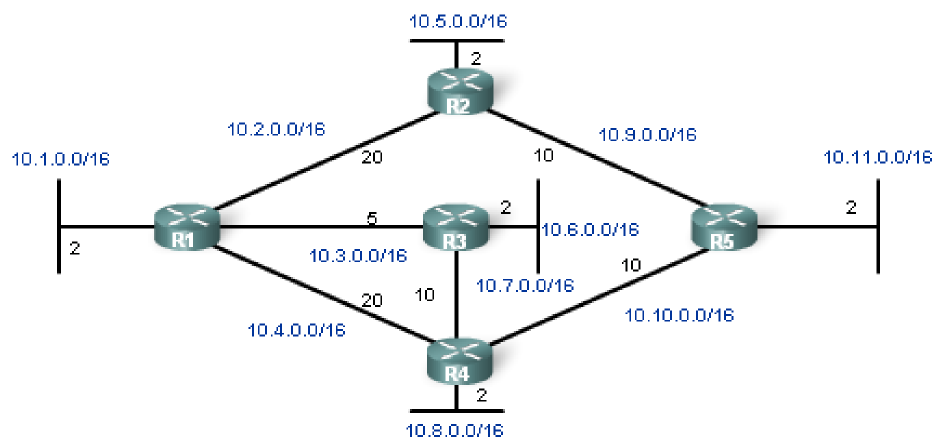
Flooding of the R1 LSP



Link-State Routing

- Constructing a link state data base
  - Routers use a database to construct a topology map of the network

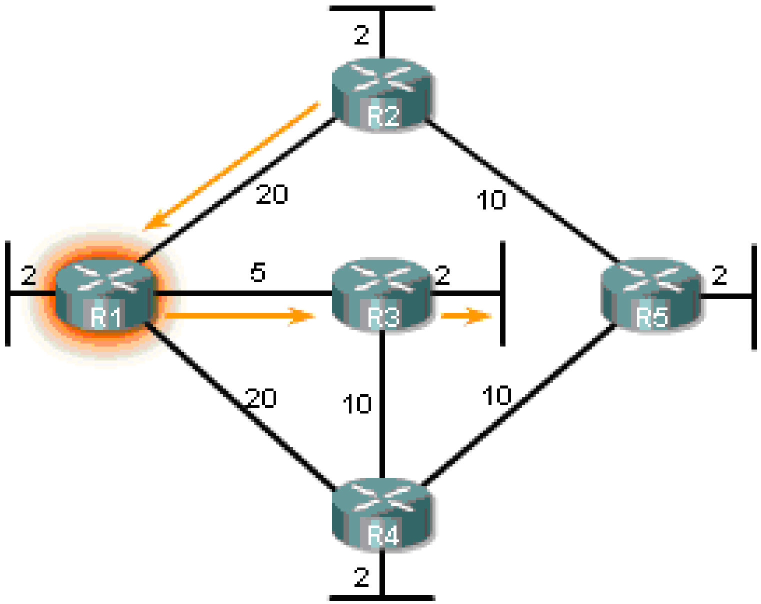
Link-State Routing Process



Link-State Routing Process

1. Each router learns about each of its own directly connected networks.
2. Each router is responsible for "saying hello" to its neighbors on directly connected networks.
3. Each router builds a Link-State Packet (LSP) containing the state of each directly connected link.
4. Each router floods the LSP to all neighbors, who then store all LSPs received in a database.
5. Each router uses the database to construct a complete map of the topology and computes the best path to each destination network.

Link-State Routing



Destination	Shortest Path	Cost
R2 LAN	R1 to R2	22
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R1 Link-State Database

R1s Link-State DatabaseLSPs from R2:

- Connected to neighbor R1 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R5 on network 10.9.0.0/16, cost of 10
- Has a network 10.5.0.0/16, cost of 2

LSPs from R3:

- Connected to neighbor R1 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.7.0.0/16, cost of 10
- Has a network 10.6.0.0/16, cost of 2

LSPs from R4:

- Connected to neighbor R1 on network 10.4.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.7.0.0/16, cost of 10
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

LSPs from R5:

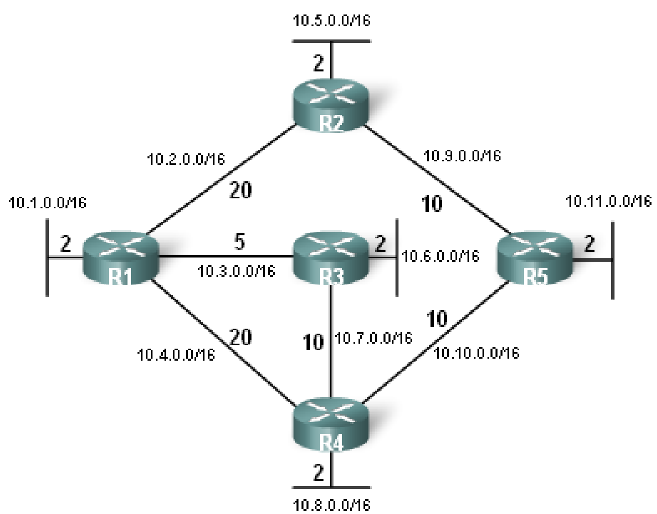
- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

R1 Link-states:

- Connected to neighbor R2 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20

Link-State Routing

- Shortest Path First (SPF) Tree
  - Building a **portion** of the SPF tree
  - Process begins by examining R2's LSP information
    - R1 *ignores* 1st LSP
    - Reason: R1 already knows it's connected to R2



R1s Link State Database

R1 Links-states:
- Connected to neighbor R2 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20
- Has a network 10.1.0.0/16, cost of 2

LSPs from R2:
- Connected to neighbor R1 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R5 on network 10.9.0.0/16, cost of 10
- Has a network 10.5.0.0/16, cost of 2

LSPs from R3:
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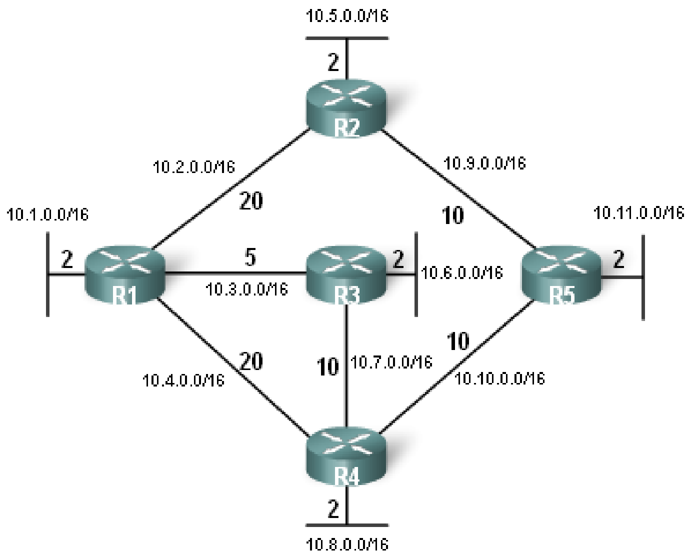
- Connected to neighbor R4 on network 10.7.0.0/16, cost of 10
- Has a network 10.6.0.0/16, cost of 2
- LSPs from R4:
- Connected to neighbor R1 on network 10.4.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.7.0.0/16, cost of 10
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

LSPs from R5:
- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

Link-State Routing

- Building a **portion** of the SPF tree
  - R1 uses 2nd LSP
    - Reason: R1 can create a link from R2 to R5 - this information is added to R1's SPF tree



R1s Link State Database

R1 Links-states:
- Connected to neighbor R2 on network 10.2.0.0/16, cost of 20
- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20
- Has a network 10.1.0.0/16, cost of 2

LSPs from R2:
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- Has a network 10.5.0.0/16, cost of 2

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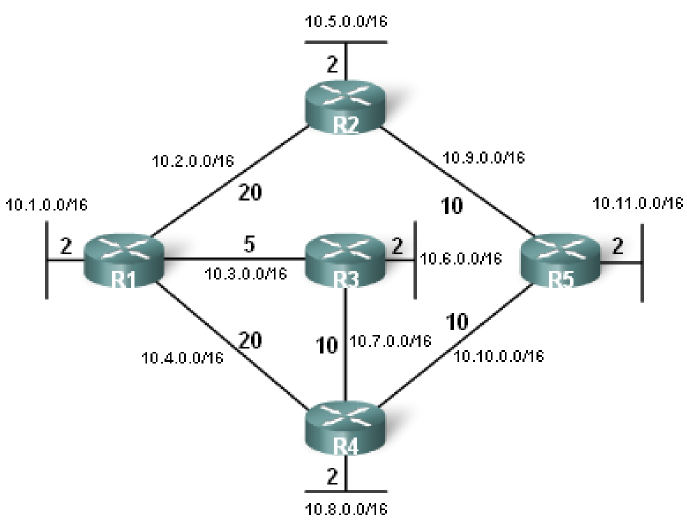
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

LSPs from R5:
- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

Link-State Routing

- Building a **portion** of the SPF tree
  - R1 uses 3rd LSP
    - Reason: R1 learns that R2 is connected to 10.5.0.0/16
    - This link is added to R1's SPF tree



R1s Link State Database

R1 Links-states:
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- Connected to neighbor R3 on network 10.3.0.0/16, cost of 5
- Connected to neighbor R4 on network 10.4.0.0/16, cost of 20
- Has a network 10.1.0.0/16, cost of 2

LSPs from R2:
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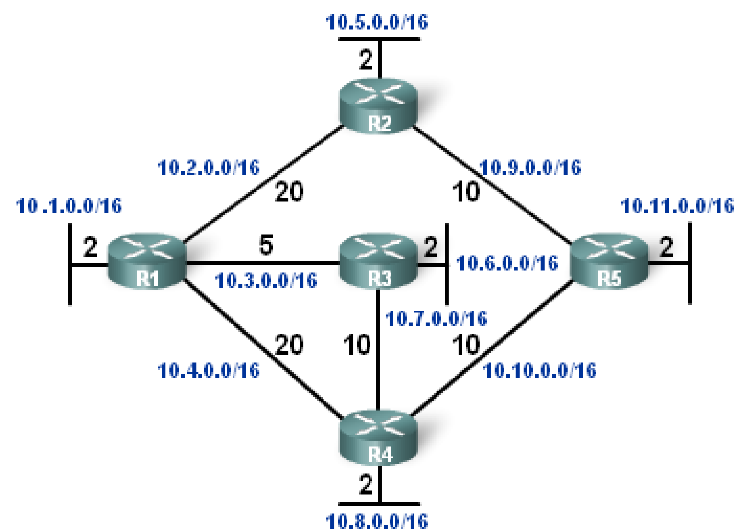
- Connected to neighbor R5 on network 10.10.0.0/16, cost of 10
- Has a network 10.8.0.0/16, cost of 2

LSPs from R5:
- Connected to neighbor R2 on network 10.9.0.0/16, cost of 10
- Connected to neighbor R4 on network 10.10.0.0/16, cost of 10
- Has a network 10.11.0.0/16, cost of 2

Link-State Routing

- Determining the shortest path
  - The shortest path to a destination determined by adding the costs & finding the lowest cost

SPF Tree for R1



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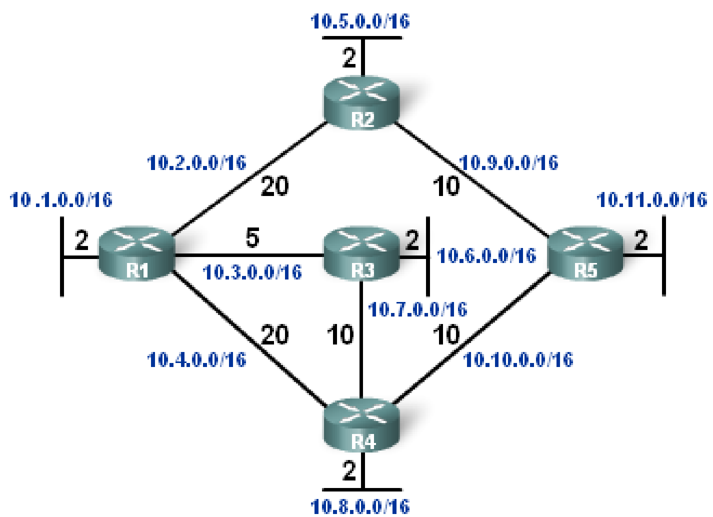
Link-State Routing

- Once the SPF algorithm has determined the shortest path routes, these routes are placed in the routing table



R1 Routing Table

SPF Information

- Network 10.5.0.0/16 via R2 serial 0/0/0 at a cost of 22
- Network 10.6.0.0/16 via R3 serial 0/0/1 at a cost of 7
- Network 10.7.0.0/16 via R3 serial 0/0/1 at a cost of 15
- Network 10.8.0.0/16 via R3 serial 0/0/1 at a cost of 17
- Network 10.9.0.0/16 via R2 serial 0/0/0 at a cost of 30
- Network 10.10.0.0/16 via R3 serial 0/0/1 at a cost of 25
- Network 10.11.0.0/16 via R3 serial 0/0/1 at a cost of 27

R1 Routing Table

Directly Connected Networks

- 10.1.0.0/16 Directly Connected Network
- 10.2.0.0/16 Directly Connected Network
- 10.3.0.0/16 Directly Connected Network
- 10.4.0.0/16 Directly Connected Network

Remote Networks

- 10.5.0.0/16 via R2 serial 0/0/0, cost = 22
- 10.6.0.0/16 via R3 serial 0/0/1, cost = 7
- 10.7.0.0/16 via R3 serial 0/0/1, cost = 15
- 10.8.0.0/16 via R3 serial 0/0/1, cost = 17
- 10.9.0.0/16 via R2 serial 0/0/0, cost = 30
- 10.10.0.0/16 via R3 serial 0/0/1, cost = 25
- 10.11.0.0/16 via R3 serial 0/0/1, cost = 27

Link-State Routing Protocols

- Advantages of a Link-State Routing Protocol

Routing protocol	Builds Topological map	Router can independently determine the shortest path to every network.	Convergence	A periodic/ event driven routing updates	Use of LSP
Distance vector	No	No	Slow	Generally No	No
Link State	Yes	Yes	Fast	Generally Yes	Yes

Link-State Routing Protocols

- Requirements for using a link state routing protocol
  - Memory requirements
    - Typically link state routing protocols use more memory
  - Processing Requirements
    - More CPU processing is required of link state routing protocols
  - Bandwidth Requirements
    - Initial startup of link state routing protocols can consume lots of bandwidth

Link-State Routing Protocols

- 2 link state routing protocols used for routing IP
  - Open Shortest Path First (OSPF)
  - Intermediate System-Intermediate System (IS-IS)

OSPF and IS-IS

OSPF

- OSPFv2: OSPF for IPv4 networks (RFC 1247 and RFC 2328)
- OSPFv3: OSPF for IPv6 networks (RFC 2740)
- OSPFv2 discussed in chapter 11

IS-IS

- ISO 10589
- Integrated IS-IS, Dual IS-IS supports IP networks
- Used mainly by ISPs and carriers
- Discussed in CCNP

Summary

- Link State Routing protocols are also known as Shortest Path First protocols
- Summarizing the link state process
  - Routers 1ST learn of directly connected networks
  - Routers then say "hello" to neighbors
  - Routers then build link state packets
  - Routers then flood LSPs to all neighbors
  - Routers use LSP database to build a network topology map & calculate the best path to each destination

Summary

- Link
  - An interface on the router
- Link State
  - Information about an interface such as
    - IP address
    - Subnet mask
    - Type of network
    - Cost associated with link
    - Neighboring routers on the link

Summary

- Link State Packets
  - After initial flooding, additional LSP are sent out when a change in topology occurs
- Examples of link state routing protocols
  - Open shortest path first
  - IS-IS